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A TEST UNIT FOR EVALUATING THE MECHANICAL ENDURANCE OF SLIDE FASTENERS (ZIPPERS)

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UNITED STATES ARMY
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SLIDE FASTENERS	TENSILE STRENGTH	
ZIPPERS	STRENGTH (MECHANICS)	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

There is a need for a reliable and reproducible means of evaluating the performance and durability of slide fasteners (zippers). No standard test procedures nor equipments are presently available. This project was undertaken to develop a slide fastener tester with operational and constructional features which would be adaptable to evaluate different sizes and types of slide fasteners under conditions simulating actual usage. These evaluations would form the basis for (1) establishing a systematic procedure of applying the proper type (cont'd)

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20 (cont'd). slide fastener in the design and manufacture of different Army items and (2) determining the acceptability of slide fasteners in DoD procurement quality assurance operations.

The work on this project resulted in the development of a prototype slide fastener tester. Its design was predicated on the operational features and controls engineered in the initial laboratory model.

PREFACE

The work on this project was performed under the Materials Testing Technology (MTT) Program administered by the Army Materials and Mechanics Research Center, Watertown, Massachusetts.

Appreciation is extended for support in this project to: Mr. John Kovar of AMEL for machining and assembling the laboratory model; Ms. Barbara Kirkwood of CEMEL for the electron micrographs, and Mr. Edward Frederick of CEMEL for his guidance on this project.

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A TEST UNIT FOR EVALUATING THE MECHANICAL ENDURANCE

OF SLIDE FASTENERS (ZIPPERS)

Introduction

There is a requirement in Federal Specification V-F-106; Fasteners, Slide, Interlocking for endurance testing of the chain according to a described device, but the use of the device in Department of Defense procurements, particularly for Army items, has been limited. The design of the testing machine included in the specification is considered inadequate because the slide fastener is tested without any of the normal restraining forces that are present in actual use. The object of this project, therefore, was to design a model of a testing unit for eventual use both as a means of rating various types of fasteners and as a quality control tool to evaluate the mechanical endurance of slide fasteners under conditions simulating actual use.

The basic mechanical problem with slide fasteners is one of interaction between the scoops, the slider, and the tape which causes the eventual failure. It is recognized that many reported failures of slide fasteners are indeed due to careless use, but in terms of usage the highest possible performance is demanded to avoid significant losses in utility with adverse effects in operating efficiency of personnel and equipments. Repairs are nearly impossible in the field. Slide fasteners are widely used by the Army and other DoD elements in such commodity areas as equipage, shelters, protective coverings for vehicles, missiles, etc., and for a range of clothing items for the military services.

Failure Analysis of Slide Fasteners

In the opening and closing motions of a slide fastener the scoops on two stringers are alternately fed in and out of each other by means of a slider. In normal use the stringer tapes are sewn into the garment and equipment, and the slider, therefore, is acting against certain restraining forces. The intensity of these forces varies depending on the usage. A longitudinal force in the direction of motion of the slider will cause severe strains thus resisting the motion of the slider. Repeated application of these forces will eventually increase the resistance to the slider motion as to permanently distort the scoops, which in turn results in malfunction of the slide fastener.

In investigations which preceded this project, a number of end items having failed, slide fasteners were examined for indications of conditions that may have initiated such failures. There was very little evidence of wear-out merely by abrasion or shaving off of metal by the action of the slider as might be duplicated by closing and opening of the fastener under favorable conditions. In most cases there was apparently a rotation or slippage of one or more scoops, which caused a significant resistance or actual jamming. Under the further pulling to overcome the resistance, scoops may have been subsequently pulled away from the tape or grossly damaged. In laboratory tests with the device specified in Federal Specification V-F-106, and minor modifications thereof, this type of failure was not observed.

In further modifications in which significant lateral tensions were imposed along the tapes ahead of and at the point of joining, these rotations and slippages were observed in some of the test tapes, which were considered either borderline in basic capacity under the loads imposed, or were thought generally inferior in quality or workmanship. One particular point of distinction was the "bite" of the scoop around the bead of the tape. Tapes which were relatively loose in degree of bite or closure of the scoop anchor around the bead appeared to be particularly prone to shifting and jamming when tested under lateral loading as shown in Figure 1.

Magnification
5X

FIGURE 1. Disorientation of Scoops

Since the lateral loading conditions applied in the laboratory experiments corresponded reasonably well to those which might be incurred in closing of a trouser fly, jacket front, sleeping bag, and other types of Army items for which slide fasteners are commonly used, it was concluded that a test device incorporating lateral restraints would be both realistic and sensitive to variables of design, quality, and workmanship in this particular respect.

Design of Laboratory Model Tester

The first phase of this work was to design a laboratory model of a testing device at the Natick Research and Development Command which could be used as a model for the fabrication of a prototype. After the initial design was modified, a laboratory model (shown in Figures 2 and 3) was finalized.

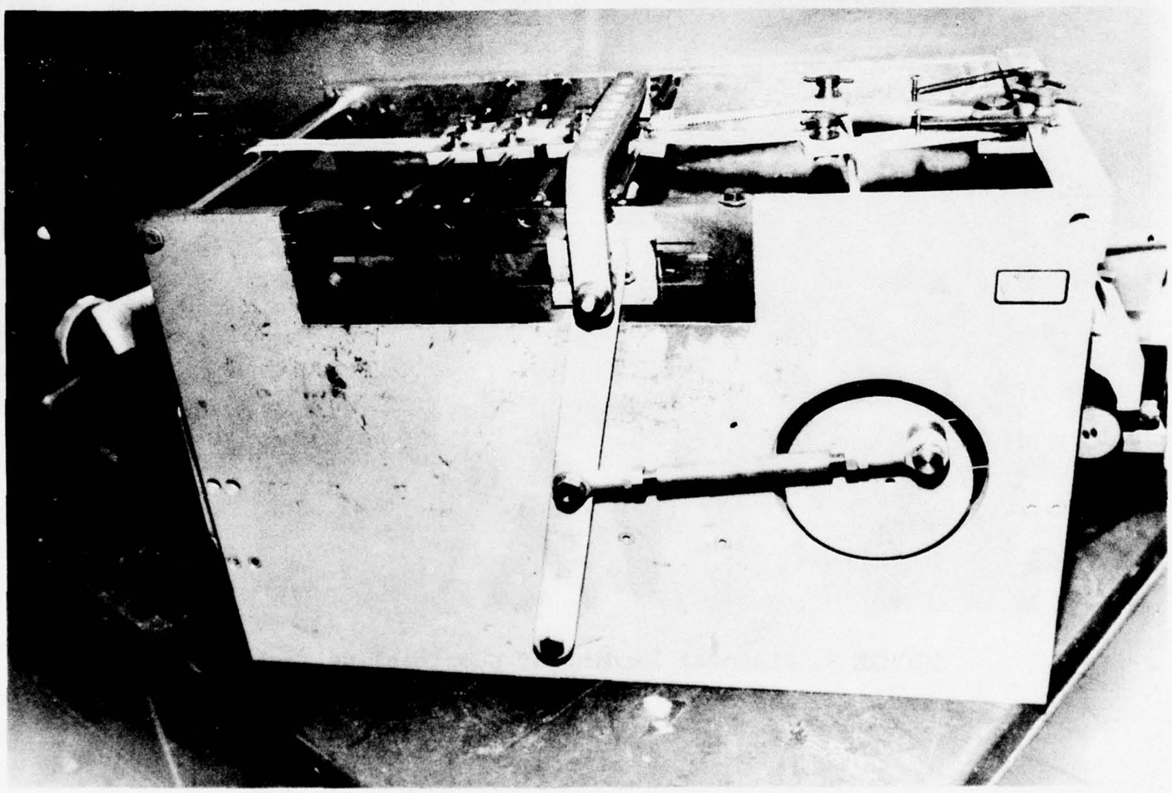

FIGURE 2. Laboratory Model Zipper Tester

This tester operates as follows:

A sample slide fastener is mounted on the device under known loads which can be varied between 0 and 5 pounds (0 and 22 N) in both longitudinal and transverse directions. The slider pull is attached to a motor driven reciprocating arm which operates the slide fastener through a distance of six inches (150 mm) at 60 cycles per minute, one opening and closing movement being recorded on a counter as one cycle. The cycle counter is capable of stopping the tester after any preset number of cycles.

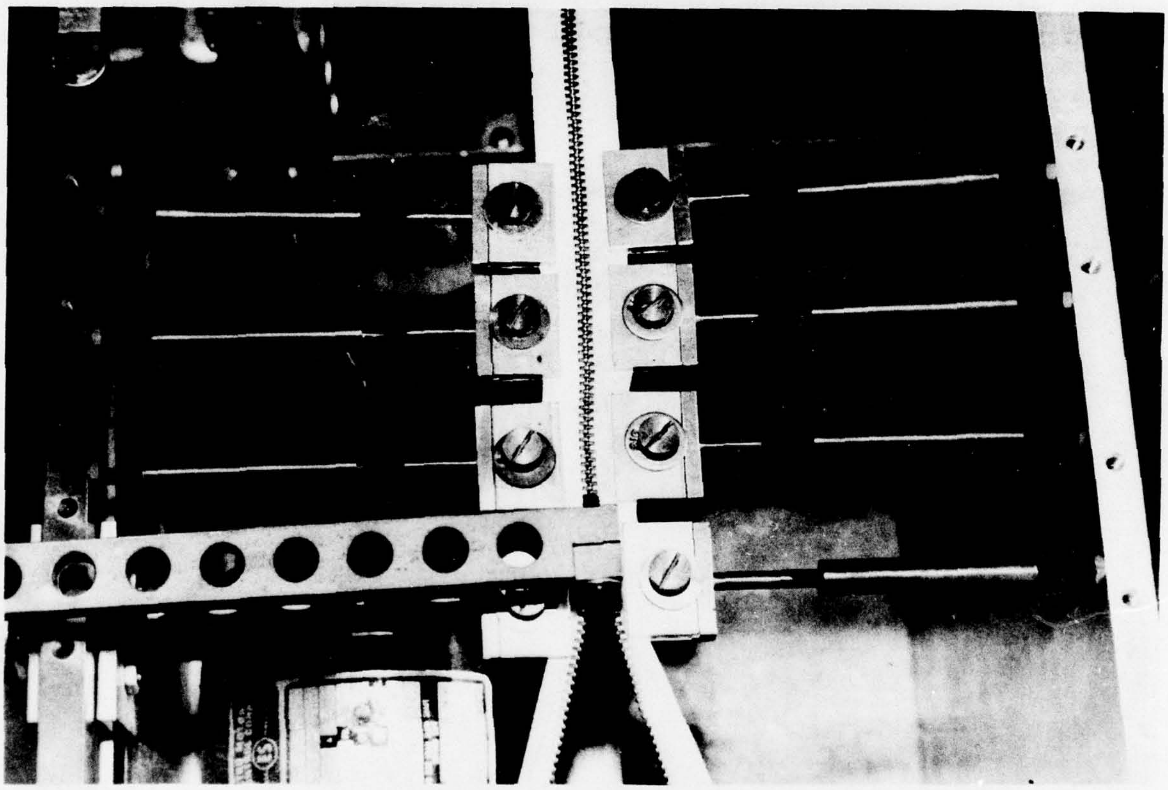

FIGURE 3. Lateral loading of sample slide fastener on the laboratory model tester.

A series of slide fasteners were tested on the laboratory model. Electron micrographs were taken of the different areas of the slide fasteners after testing, then studied for wear patterns. Figures 4, 5, 6, and 7 illustrate the types of wear observed on slide fasteners tested on the laboratory model. During this experimentation it was observed that the wear on the different mechanical parts eventually affects the ease of operability of the slide fastener. An attempt was made to measure the progressive effect by means of hand-held tension-compression measuring devices. This procedure required the detachment of the slider from the reciprocating arm and measuring the opening and closing forces after every specific number of cycles. Because of the changes in mounting configuration caused by this procedure, it was not possible to make reproducible measurements. The need for continuous monitoring of these forces was, therefore, recognized.

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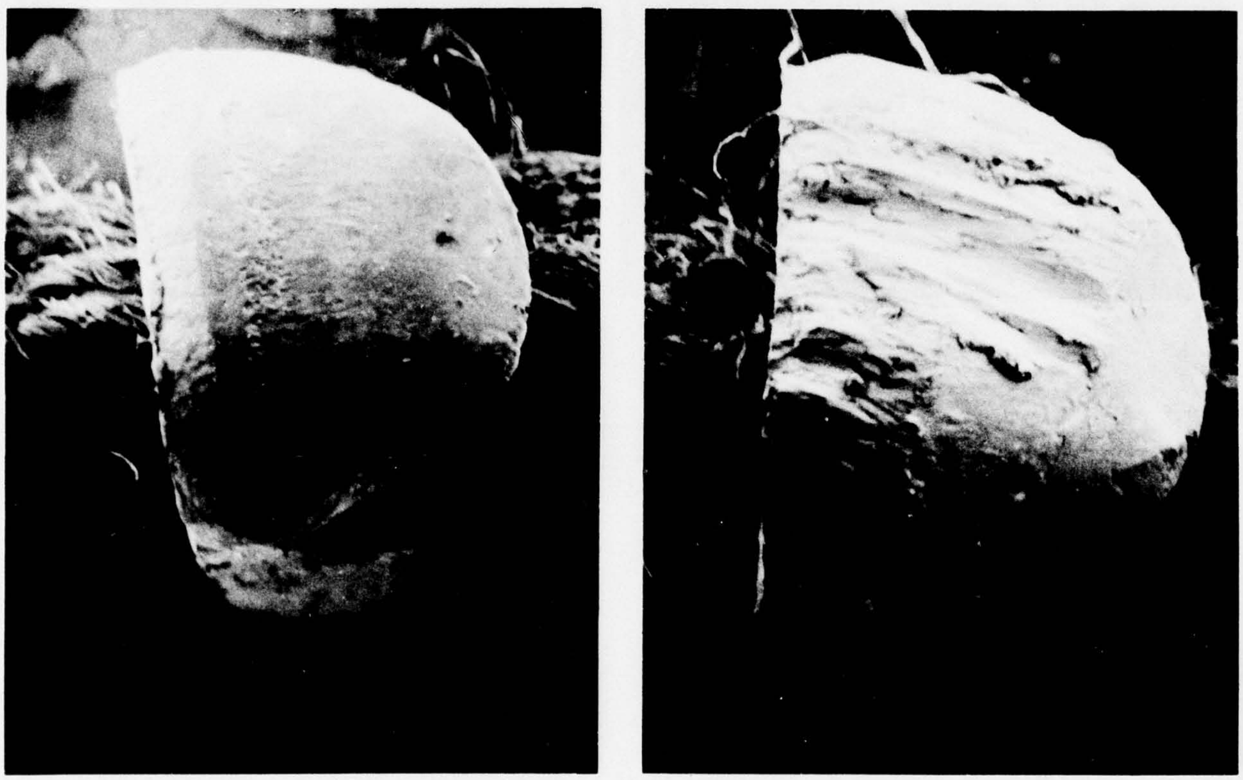

Before After

FIGURE 4. Appearance of a single scoop before and after being subjected to 10,000 cycles of wear under 4 lb (18 N) of lateral and longitudinal forces.

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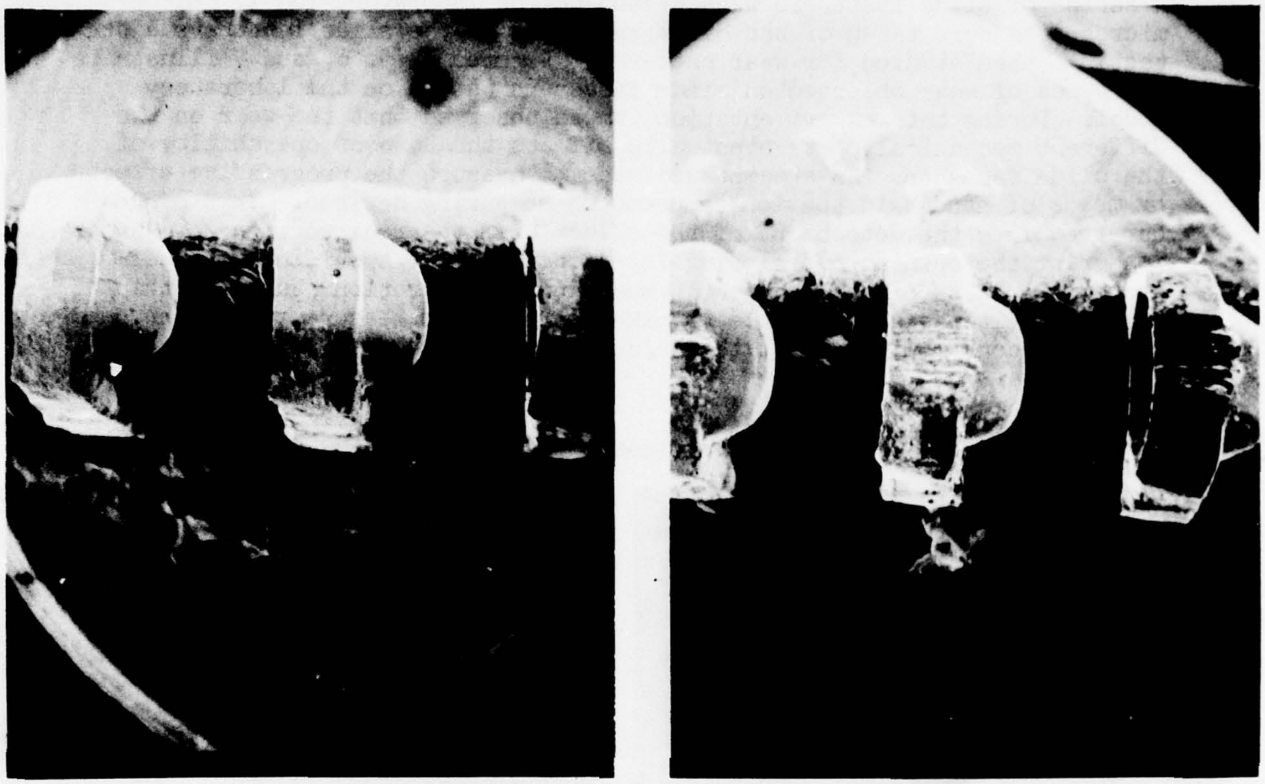
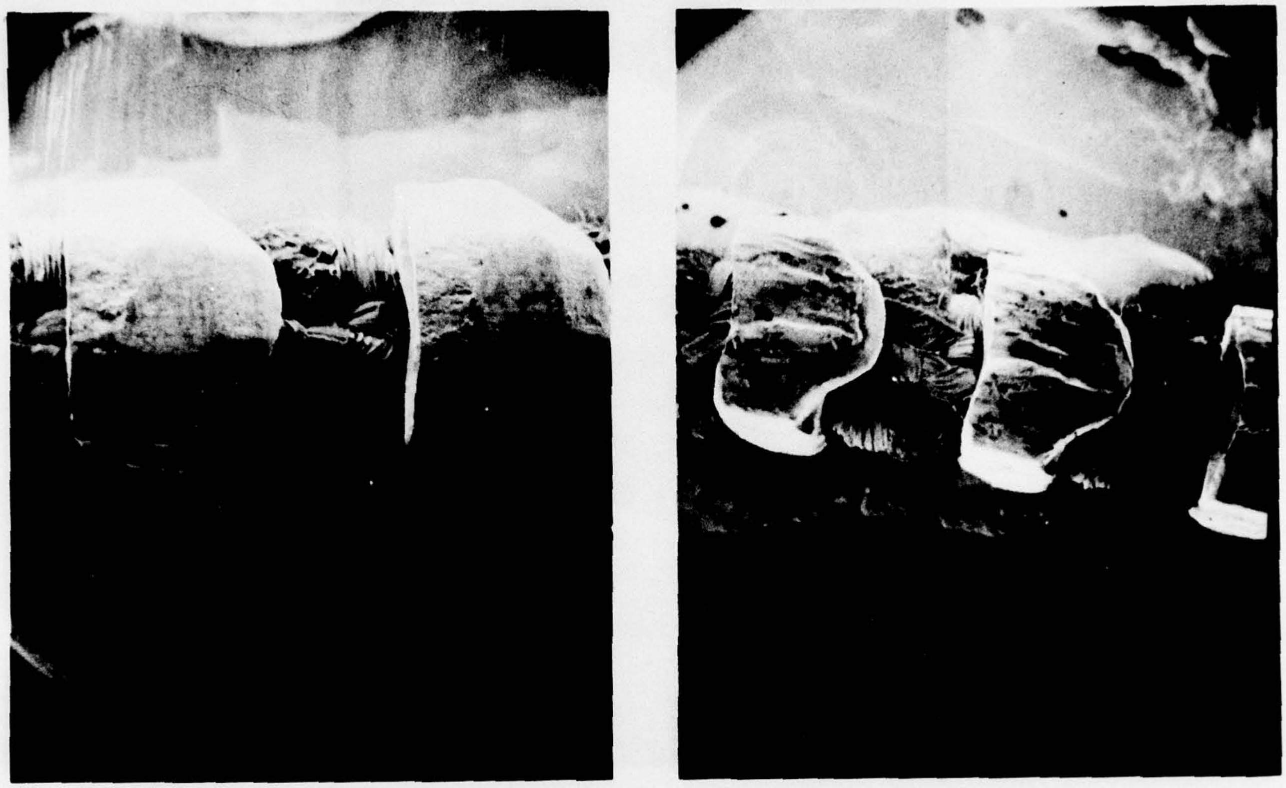


Before

After

FIGURE 5. Slide fastener scoops before and after 10,000 cycles of wear on the tester under 2 lb (9 N) lateral and 1 lb (4.5 N) longitudinal forces.



Before

After

FIGURE 6. Slide Fastener scoops before and after 10,000 cycles of wear on the tester under 2 lb (9 N) lateral and 1 lb (4.5 N) longitudinal forces.

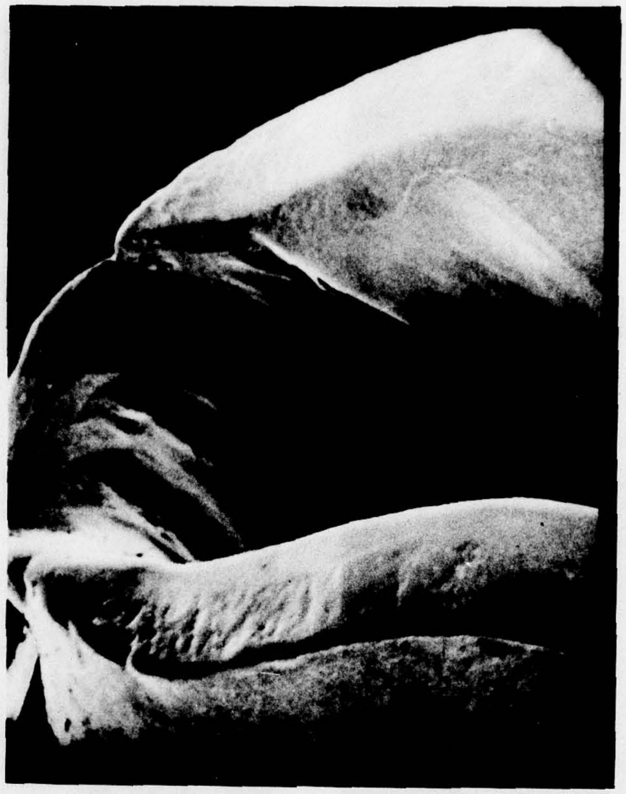


FIGURE 7. Wear on the throat of the slider of a zipper which jammed on the tester at 8,500 cycles.

Prototype Slide Fastener Tester

During the second phase of this project a contract was awarded for the construction of a prototype model. The services of an engineering firm specializing in instrument manufacture were engaged to produce a heavy duty version of the laboratory model. The prototype model would have to withstand frequent usage as a quality control device.

The specifications for the key features of the prototype model are as follows:

(1) provision for mounting slide fasteners of different lengths with a minimum of 6 inches (150 mm).

(2) provision for attaching the slider to a motor driven reciprocating arm and to open and close mechanically the slide fastener at 60 cycles per minute.

(3) provision for a cycle counter which will stop the device at any preset number of cycles up to five digits.

(4) provision for applying a longitudinal load on the slide fastener from 0 to 5 pounds (0 to 22N) in 1-pound (4.5 N) increments.

(5) provision for applying a transverse load 0 to 5 pounds (0 to 22 N) in 1-pound (4.5 N) increments in the portion of the slide fastener where the reciprocating arm is operating the slide.

(6) provision for continuously monitoring the opening and closing force and to stop the machine when the force reaches a preset level.

(7) provision for the location of controls and adjustments to facilitate ease of operation and safety.

(8) provision for measuring and recording force applications on slide fastener while being tested.

The overall view of the tester is shown in Figure 8. All of the mechanical and electrical components necessary to accomplish the various functions are inclosed in the metal box on the left. The operational portion of the tester is under a plexiglass cover on the right with a safety switch that will shut the motor off if the cover is lifted when the tester is running.

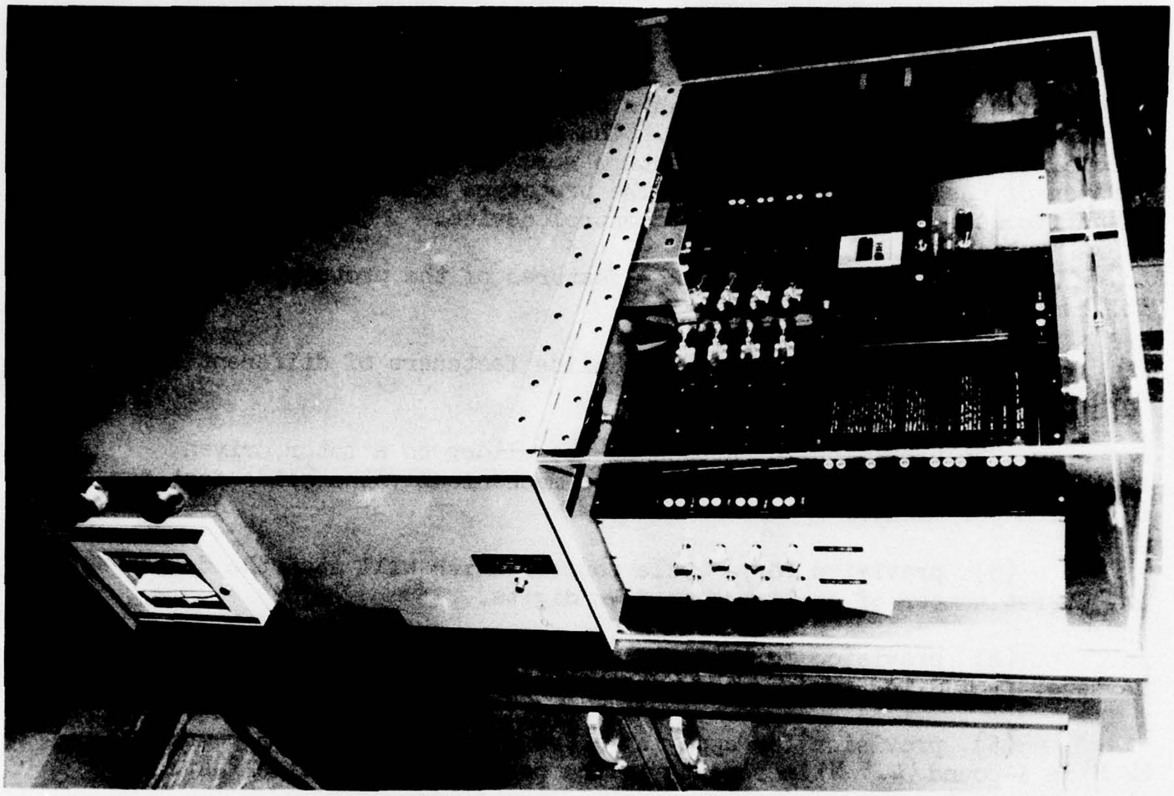


FIGURE 8. Prototype Zipper Tester

The lateral loading clamps are shown in Figure 9. The clamps are quick loading type to reduce the time required to mount sample. Four pairs of clamps accomplish the same function as the clamps on the laboratory model shown in Figure 3. The loads on these clamps can be varied in increments of 500 g (5 N) up to 2.5 kg (25 N). There is a clamp for the same loading purpose in the longitudinal direction.

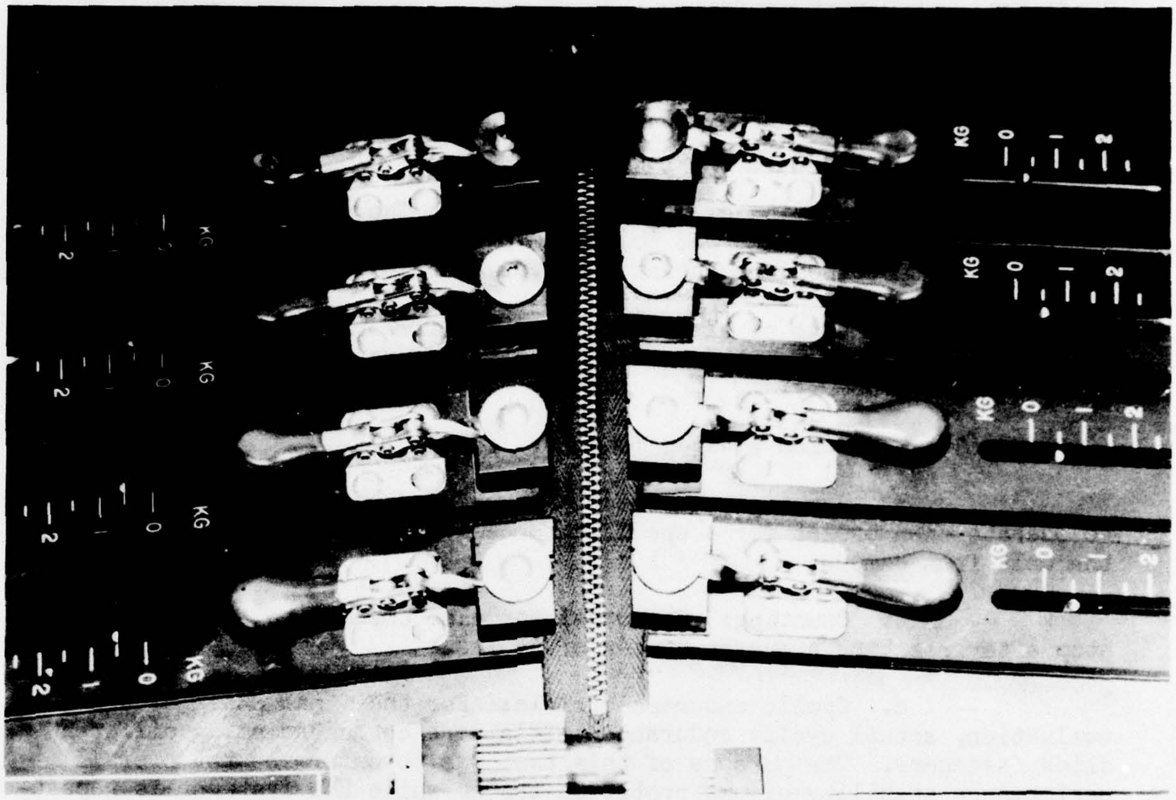


FIGURE 9. Lateral loading clamps of the prototype tester

The key features of the prototype unit are described and illustrated in the Appendix.

Performance of Prototype Tester

A series of test routines was scheduled and conducted on the prototype unit to assess its performance in meeting the requirements of this project.

The initial phase involved a check for:

(1) Functioning of parts/components: The unit was operated for a minimum of 10,000 cycles and observed for proper operations of unit elements and smoothness of operation; i.e. absence of vibrations, noise, etc.

(2) Mounting of slide fasteners: Different lengths and sizes of slide fasteners were mounted on the model to assure that test specimens can be positioned properly.

(3) Operation of stop motions:

a. Jamming: The model was checked to see that it would cease to operate when preset for a specific force level, as a means of protecting the unit from damage.

b. Counting: The model was also checked to see that it would stop after reaching a preset number of cycles.

c. Cyclic endurance trials: For the final phase of the evaluation, actual cyclic endurance trials were conducted using different slide fasteners. The purpose of this test was to determine the overall performance stability of the prototype tester while the fastener is repeatedly being opened and closed under both longitudinal and transverse loads. See Figure 9.

The assessment of the performance test is as follows:

The device performed satisfactorily in all the above evaluations. The only problem was with the opening and closing force sensor. Apparently the manufacturer has used a strain gage unit that is extremely sensitive to temperature and humidity without compensation in the circuitry. This has resulted in a constant drifting problem with the recorder. Further modification of the force recording system is being planned with the assistance of NARADCOM electronics shop personnel. However, the mechanical portion of the tester was found to be completely satisfactory.

Conclusions and Recommendations

The performance of the prototype model demonstrated that the primary objectives of the project were achieved; namely, (1) making possible the use of a test mode which is more indicative of actual usage conditions of slide fasteners, and (2) providing greater test equipment control and protection during usage. Modifications will be made to correct the drift problem encountered with the recorder.

The following recommended actions will be taken to implement the use of the slide fastener tester:

(1) The tester will be used to evaluate a range of slide fasteners with a view to determine if they can be classified for most efficient usage based on their basic performance capacity, in addition to their other physical parameters.

(2) The tester will also be used for quality assurance purposes in an attempt to eliminate poor quality slide fasteners from the DoD supply system by providing a common basis for competitive bidding. A revised test mode may make this possible and also may permit reducing the presently established 10,000 cycles of test, thereby expediting testing and reducing test costs.

(3) Industry representatives will be invited to see the demonstration of the tester and will be kept informed of the developments.

(4) After necessary modifications are made and the tester proves successful, action will be initiated to incorporate the device in the Slide Fastener Specification, V-F-106.

(5) Attempts will also be made to incorporate the tester in the American Society for Testing and Materials (ASTM) Standard's zipper test methods.

APPENDIX

Appendix

Description of Prototype Features

The mounting and operating instructions are shown on a plate mounted directly on the tester. This plate is shown in Figure 10. The step-by-step instructions with indicator lights which turn on sequentially eliminate the need for an instruction manual.

The loading of the slide fastener through the clamps numbered 1 through 9 is accomplished with 9 pairs of load and status knobs shown in Figure 11. Four pairs of these knobs are located on either side of the tester and the fifth is in the front. The status knobs turn either "load" or "ready" indicator lights depending on the direction of rotation of the knob. The purpose of these knobs is to advance the clamps so that the zipper can be mounted before the load application. The tester cannot be operated unless the sequential instructions are followed. The operational side of the tester with all the indicator lights discussed is shown in Figure 12.

There is a load cell mounted on the reciprocating arm attached to the slider pull. The load cell accomplishes two purposes. First is to record the opening and closing forces on a strip chart recorder shown in Figure 13, mounted on the side of the tester. Second is to send a signal to stop the tester when this load exceeds the limits set on the gauge shown in Figure 14. The tester also stops when the number of cycles set on the cycle counter is reached. With this arrangement, need for the presence of an operator at the side of the tester during test is eliminated. When the laboratory model was being evaluated, it was observed that in order to avoid damage the tester must be stopped as soon as the zipper jammed. The overload stopping mechanism built into the prototype accomplishes this automatically.

The load cell is calibrated as with any other load cell by directly hanging a weight and adjusting the deflection on the recorder. Figure 15 illustrates the calibration procedure. It is necessary to install the calibration pulley by means of two screws and the load attached by a wire. Calibration instructions with the necessary accessories are provided with the tester.

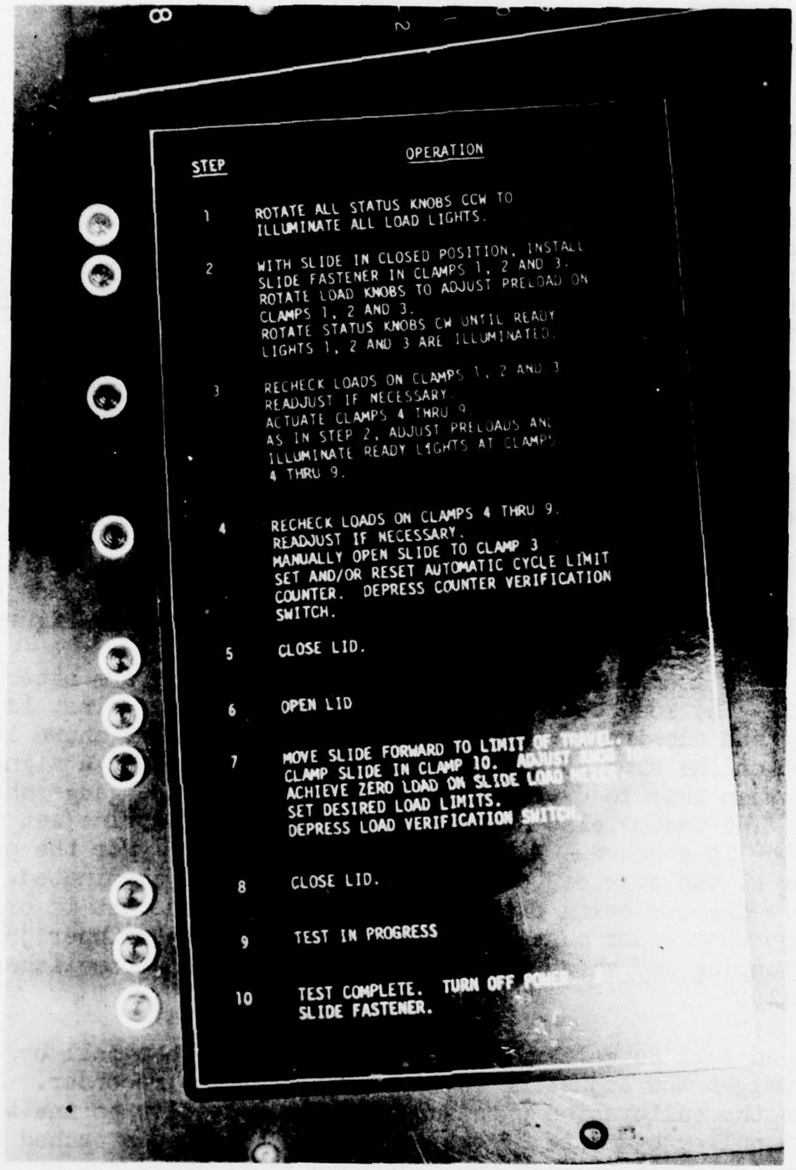


FIGURE 10. Operation instructions with sequential indicator lights.

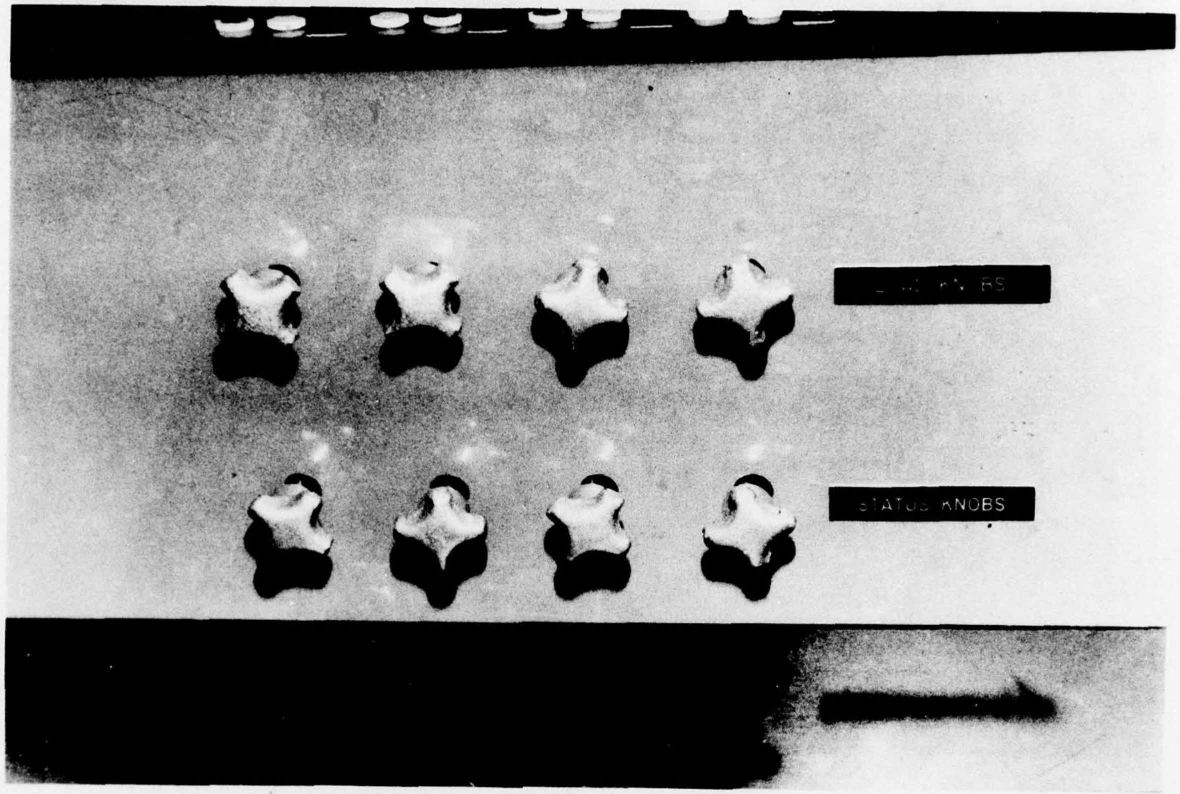


FIGURE 11. Load and status knobs for load application.

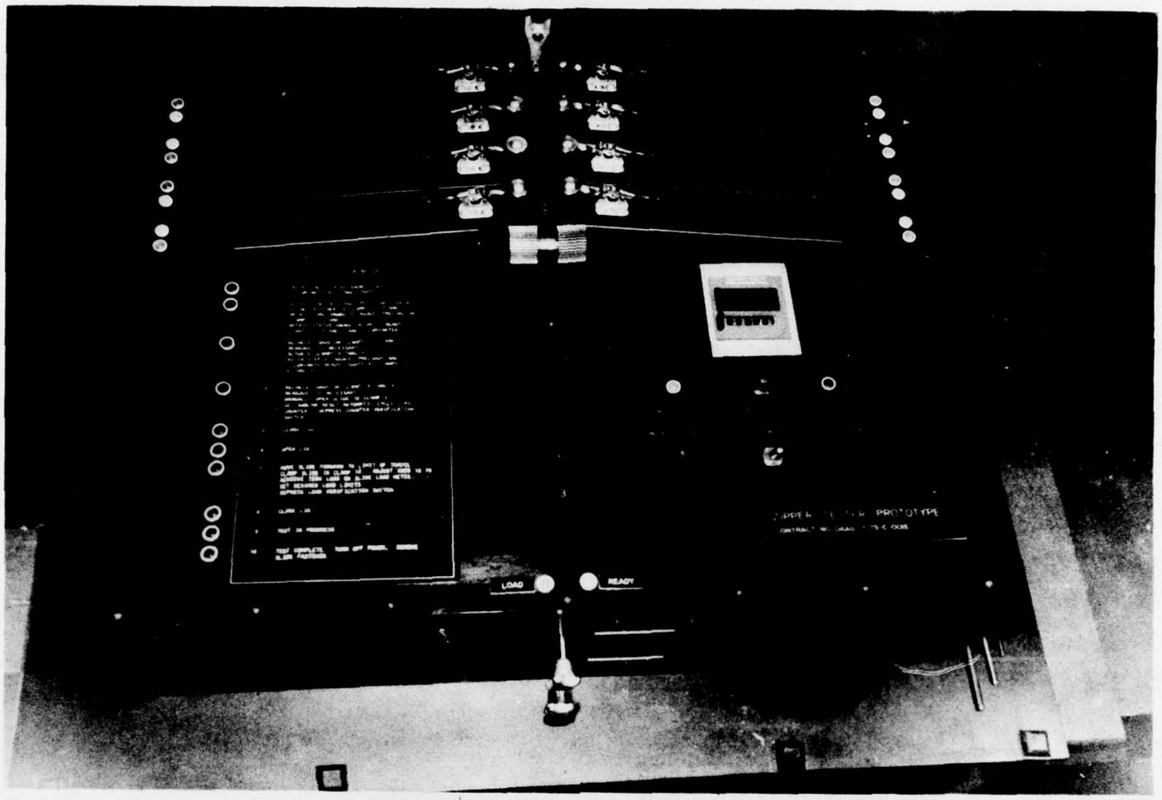


FIGURE 12. Zipper in test position.

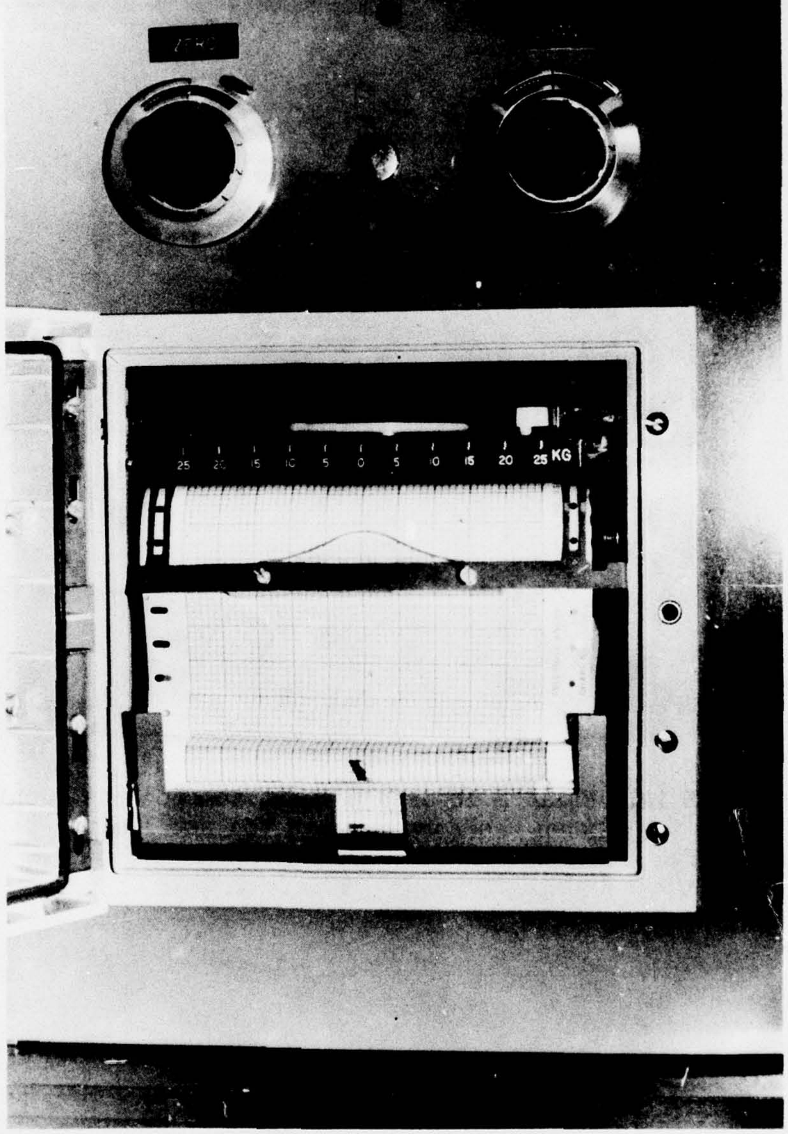


FIGURE 13. Chart to record the opening and closing forces.

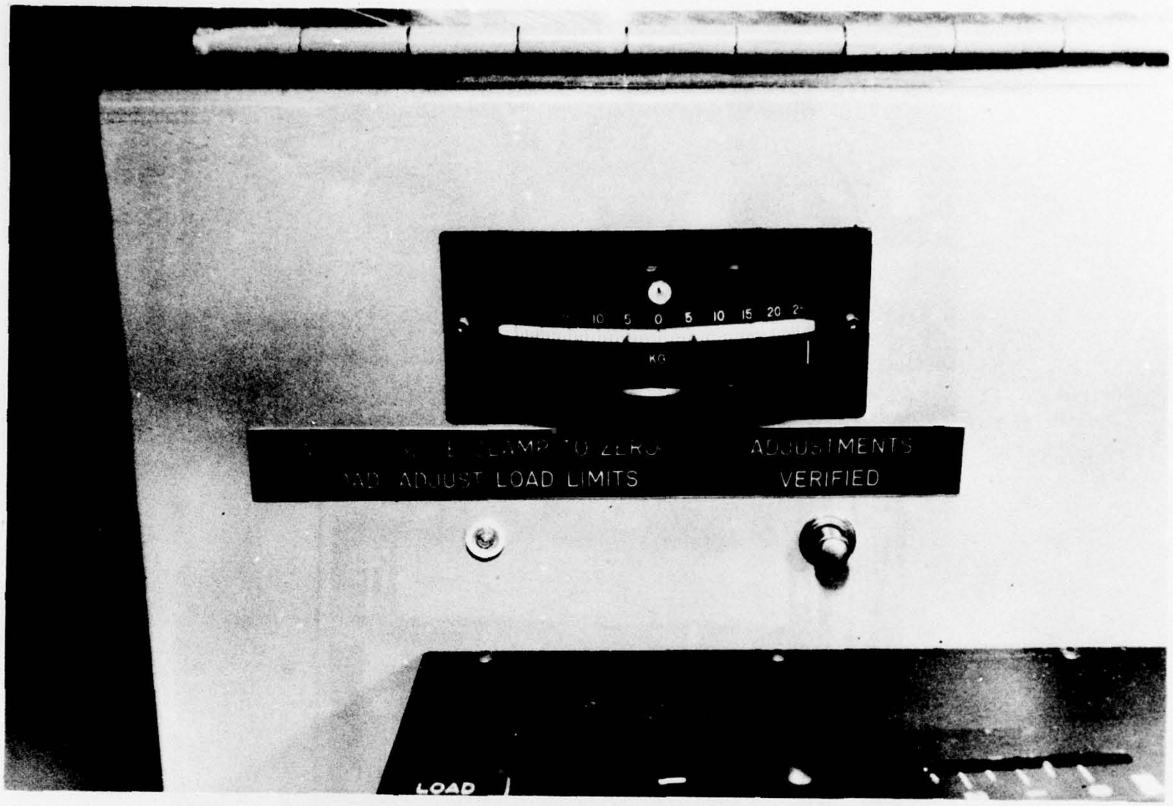


FIGURE 14. Maximum load adjustment to stop the machine when the forces reach the set limit

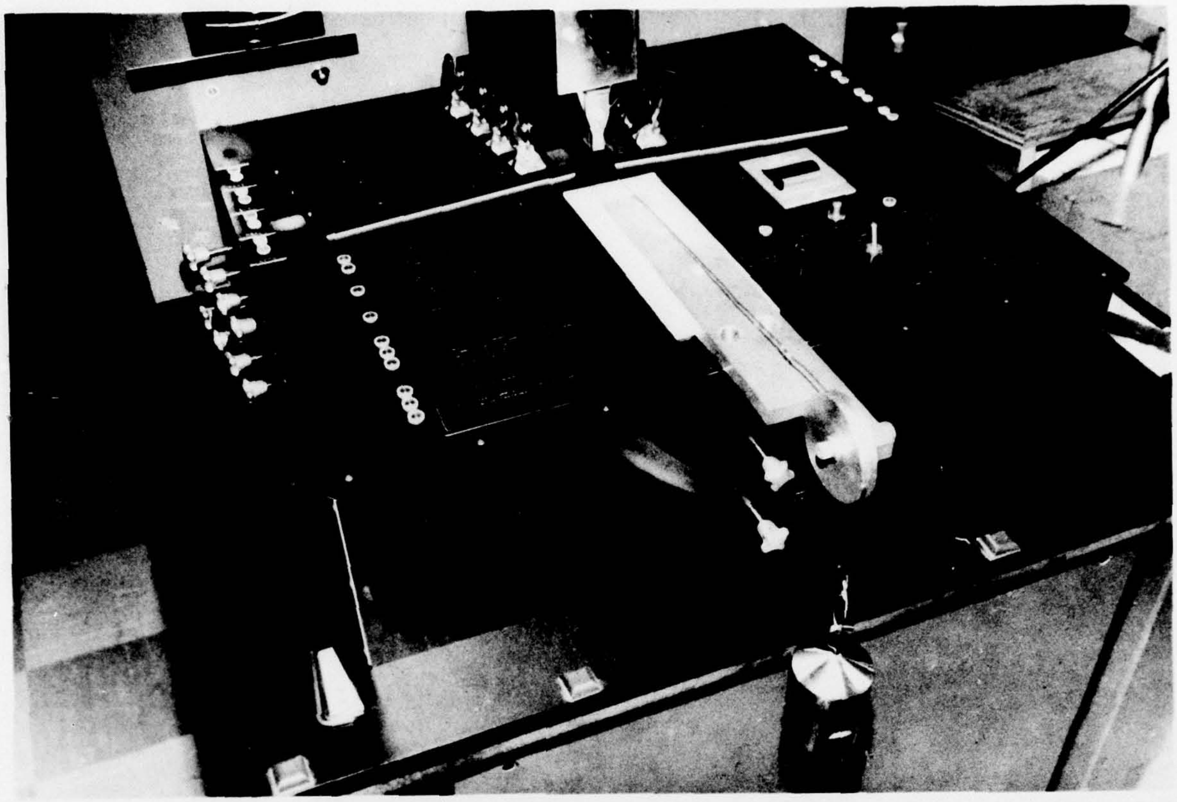


FIGURE 15. Calibration of load cell
on the reciprocating arm.